FOOD TECH PLATFORM FINLAND
Fact sheet

GENETICALLY MODIFIED FOOD

Let's talk about GM food

As climate change and population growth threaten the world's food system, global hunger grows. Genetic modification and editing technologies may be able to help feed many of those in need. These technologies can add significant value to current plant breeding by, for example, improving resilience and decreasing the need for harmful pesticides.

However, European Union legislation has failed to keep up with technological development. European companies and researchers are either at a standstill or lagging behind market leaders in plant breeding, such as the United States, China and Argentina. While researchers have identified the potential of genetic modification, customers remain distrustful of GM foods.

Keep reading to find out

- what the situation is with EU regulation (and whether it's working)
- what's going on in GM research
- is the business blooming
- what the general public thinks about gene modification (and why)

See last page for a quick summary!

Hello, reader!
You're holding a fact sheet produced by Food Tech Platform, an Allied ICT Finland network orchestrated by the University of Turku. This leaflet provides you with an easily approachable overview of the current state of genetically modified foods. It covers the topic from four different points of view:

- LEGISLATION
- SCIENCE & RESEARCH
- BUSINESS
- CONSUMER BEHAVIOR

LEGISLATION
In Europe, both GM regulation and applications are lagging behind

Since the early 1990s, European Union regulation on genetically modified organisms has had two main objectives: to protect health and the environment, and to ensure the free movement of safe and healthy GM products in the EU. The regulation includes a risk assessment directive, which requires GMO developers to go through a time-consuming and expensive process to ensure the products' overall safety before entering the market.

While GM research has taken big strides forward, EU legislation has failed to keep up with the developments. With the rise of new gene editing technologies (such as CRISPR-Cas), Europe's highest court ruled in 2018 that gene-edited crops will be subject to the same strict regulations as traditional GMOs, despite significant differences between the two. As long as gene-edited varieties have to follow GMO rules, plant breeders in Europe will have little to no chance of utilizing these new technologies in their development efforts. This leads us to where Europe is now: lagging behind the United States, Argentina and China.

The EU needs to update its directives so that Europe will not lose its competitive advantage in developing and producing future-fit crops, especially in the face of climate change. In comparison, Argentina has taken regulatory actions that aim to shorten the approval time of new genetically modified crops from 42 months to 24 months. The Argentinian government has established a case-by-case assessment process to determine whether a new crop needs to be regulated.[1]

As important as it is to guarantee the safety of gene modification technologies, current European legislation is challenging. It hinders research and development, hampers any efforts for funding, and makes it very difficult for small companies to gain access to GM markets.

THE EU'S CONFUSING DEFINITIONS

New gene biotechnology methods (e.g. gene editing such as CRISPR-Cas) can produce plants that don't contain foreign DNA and therefore should *not* be called GMOs.

Current EU legislation has been strongly criticized because it categorizes gene-edited products (such as gene-edited crop plants) as GMOs even when they do *not* contain foreign DNA.

There is strong pressure for EU legislation to free gene-edited plants and microbes from the strict GMO legislation. According to researchers, the specific regulation should concern the product – the end result of modification and editing – and not the technology.

KEY TERMS

GM Genetic modification. An area of biotechnology that concerns the manipulation of the genetic material in living organisms to enable them to perform specific functions.

GMO A genetically modified organism. Produced by gene technology and contains foreign DNA.

GM foods Foods produced from or using genetically modified crops, which can be GMOs (contain foreign DNA by definition) or gene-edited (may not contain foreign DNA, but simply their own altered DNA).

SCIENCE & RESEARCH
Despite breakthroughs, GM research is a tough field

Despite recent groundbreaking gene editing technologies (such as CRISPR-Cas) and product innovations (such as GM salmon), GM research hasn't exactly been the ideal field for researchers in the last decades. They've had to put a lot of work into convincing consumers that genetic modification is no riskier than conventional plant breeding.

The EU, for instance, has invested over 300 million euros in GMO biosafety research.[2] A 2016 consensus report by The National Academies of Sciences Engineering and Medicine stated that there was no connection between gene-edited crops and environmental problems. There was also no evidence that gene editing tech had helped increase crop yields in the US. However, according to a global meta-analysis of 147 published biotech crop studies over the last 20 years, GMO technology adoption has, on average, reduced chemical pesticide use by 37 percent, increased crop yields by 22 percent and increased farmer profits by 68 percent.[3]

Outside safety research, these issues have been on researchers' plates and in their plans:[4]

- genome-edited, disease-resistant rice and wheat
- drought-tolerant maize
- early-yielding tomatoes
- golden rice (prevents vitamin A deficiency)
- nanotechnology in plant engineering
- disease-resistant bananas, wheat and potatoes
- drought-tolerant sugarcane

Despite their efforts in basic research, scientists have been hitting a wall when trying to turn their ideas into practical applications. Strict EU legislation, a global market dominated by a handful of massive companies and general mistrust in genetic engineering hinder applied research.

European scientists will continue to use gene editing technology as a tool, but funding remains a challenge. To many, this is a shame, since GM technologies could play a very important role in mitigating climate change and alleviating world hunger. Functional new applications require high-quality research and testing.

WHAT IS CRISPR-CAS?

CRISPR-Cas, which first appeared in 2007, is a popular technology for editing genomes, i.e., altering DNA sequences and modifying gene functions. The CRISPR mechanism exists naturally in all kinds of bacteria for fighting off viruses, and was developed into the currently known gene editing tool by scientists over the past couple of decades.

It particularly has potential for the prevention and treatment of human diseases, as well as for advanced plant breeding, but it does raise ethical concerns. The technology has generated a lot of excitement since it's faster, cheaper and more efficient than its predecessors.

BUSINESS
The GM crop market is dominated by a select few

In 2018, 21 developing countries and 5 industrialized countries planted 191.7 million hectares of GM crops worldwide. However, as of late, the industry has entered a stagnant period and its growth depends on R&D of new products and the deregulation of emerging markets.[5]

Approximately 33% to 36% of the global seed market, estimated at 55–61 billion USD in 2019, is GM seeds. Currently, the GM seed market is dominated by five international companies, or the "Big Five". In 2016, Monsanto, Bayer CropScience, Dupont, Sygenta and Groupe Limagraina accounted for 70% of the global market.[6]

These players are acquiring smaller competitors and forming joint ventures, which strengthens their position as entry barriers for the GM crop industry. In terms of R&D for GM technology, the United States and China are leaders, whereas Southeast Asia, India and developing countries still have a long way to go.

In Europe, the situation is somewhat less liberal than in the leading countries. In 2019, only one GM crop, corn, was planted in Europe – specifically in Spain, Portugal, Czech Republic and Slovakia. Over a dozen European countries have opted out of GM cultivation. Overall, the cultivation of GM crops in the EU is limited to less than 0.1% of the global volume, which is 337,000 acres.[7] As the testing and cultivating of gene-edited crops in nature is almost entirely prohibited, applied research and developing new features in plants isn't done in Europe.

In Africa, the GM market is estimated to reach 871 million dollars by 2025. Nigeria recently became the first country ever to approve GM cowpea seeds that are modified to reject destructive attacks by winged pests. However, in addition to long trial processes, African countries are burdened by European legislation. They fear GM crops will affect trade flows with Europe, Africa's largest export market.[8]

On the one hand, consumer attitudes, government regulation and potential health risks affect the GM market negatively. On the other hand, the increase in agricultural

productivity, the decrease in need for harmful pesticides, and investments in biotech R&D drive the market.[9] According to research findings, GM companies have had a high return on equity, but also a high level of risk.[10] Eventually the fate of GM food producers, distributors and retailers boils down to one key issue: whether people accept or reject GM foods.

GM FOOD CONSUMPTION

Processed foods that contain genetically modified crops, such as corn and soy, have become quite common in some parts of the world. Approximately 70 % of processed foods sold in the US contain GM crops, whereas in Europe the figure is only about 5 %. [11]

CONSUMER BEHAVIOR
They have the facts and they're voting no – consumers worry about GM food

Despite decades of research on GM and GMO safety, consumers remain unconvinced. Take China, for example, which is one of the leading countries in genetically modified produce. According to a nationwide Chinese consumer study, after 25 years of R&D, roughly 47% of respondents still have a negative view of genetically modified food.[12]

Consumer attitudes play a crucial role in how gene editing is perceived in politics and business. Based on previous studies, there are at least three main things that affect consumer behavior: *socio-moral attitudes*, *lack of trust* and *contradictory communication*.

First, the dichotomy between naturality (good) and gene editing (bad) is an important attitude factor. People perceive GM food as unnatural and thus unappealing, or even morally questionable – as if gene editing would mess with the natural order of... well, nature. However, plant breeding has existed long before GM technologies.

Second, a lack of trust in the institutions handling genetic engineering technologies may create prejudice towards GMOs and GM food. The agricultural industry, regulators and scientific institutions are under a lot of critical scrutiny.[13]

And third, when it comes to communication, rigorously tested scientific findings should assure consumers. But for each reassuring research paper there's another fear mongering one available. Simultaneously, consumers are surrounded by companies that declare themselves "GMO free", and social media provides efficient channels for disseminating information and opinions. There's an ever-growing need for dialogue between laypeople, businesses, researchers and decision makers on the pros and cons of GM foods.

REFERENCE LIST

1. Cerier, S. 2018. Argentina and GMOs: Exploring the nation's long relationship with biotech crops. Referenced on 26.3.2020
2. American Association For the Advancement of Science. 2012. Statement by the AAAS Board of Directors On Labeling of Genetically Modified Foods. Referenced on 26.3.2020
3. Klümper, W. & Qaim, M. 2014. A Meta-Analysis of the Impacts of Genetically Modified Crops.
4. Watson, D. 2019. Genetically Modified Crops in Agriculture. Scientific e-Resources.
5. Zhang, J. 2019. 2019 Overview of Global GMO Development. Referenced on 26.3.2020
6. Raman, R. The impact of Genetically Modified (GM) crops in modern agriculture: A review. *GM Crops Food*. 2017; 8(4): 195–208.
7. Tagliabue, G. The EU legislation on "GMOs" between nonsense and protectionism: An ongoing Schumpeterian chain of public choices. *GM Crops Food*. 2017; 8(1): 57–73.
8. Kede, S. 2019. GM foods: The battle for Africa. Referenced on 26.3.2020
9. Kenneth Research. 2019. GMO Crops Market Is Estimated To Expand At a Healthy CAGR in the Upcoming Forecast 2025. Referenced on 26.3.2020
10. Russell, H., Durr, D. W., Smith, R., Murphy, C., & Finke, A. 2017. Analysis of GMO Food Products Companies: Financial Risks and Opportunities in the Global Agriculture Industry. *African Journal of Economic and Sustainable Development*, Vol. 6, No. 1, pp. 1-17.
11. Diehl, P. 2019. Genetically Modified Food. Referenced on 26.3.2020
12. Cui, K. & Shoemaker, SP. 2018. Public perception of genetically-modified (GM) food: A Nationwide Chinese Consumer Study. *NPJ Sci Food*. 2018 Jun 5;2:10. doi: 10.1038/s41538-018-0018-4. eCollection 2018.
13. Siegrist, M. 2006. A Causal Model Explaining the Perception and Acceptance of Gene Technology. *Journal of Applied Social Psychology* 29(10):2093–2106.

SUMMARY

GENETICALLY MODIFIED FOOD

Let's talk about GM food

We hope this leaflet gave you some food for thought. Take your time to digest it! But if you're feeling too full, you can take these bites with you.

LEGISLATION

GM research has taken big strides forwards. EU legislation has not.

SCIENCE & RESEARCH

Despite their efforts in basic research, many factors hinder scientists when they try to turn their ideas into practical applications.

BUSINESS

Eventually the fate of GM food producers, distributors and retailers boils down to one key issue: whether people accept or reject GM foods.

CONSUMER BEHAVIOR

Consumers remain unconvinced about GM food despite decades of research. There's an ever-growing need for dialogue between laypeople, businesses, researchers and decision makers.

Let's start a dialogue! Contact the Food Tech Platform Programme Leader Laura Forsman (laura.forsman@utu.fi) and start something exciting.

Food Tech Platform Finland is a food focused research-business network in Finland that brings together companies, startups, science and education communities, and the public sector. Its ambitious aim is to develop a sustainable Food System 2.0. For this purpose, it facilitates the breeding of science-based food innovations and novel business propositions. Food Tech Platform Finland is an Allied ICT Finland powered growth network and is orchestrated by the University of Turku.

Food Tech Platform finland

Leverage from the EU 2014–2020 European Union European Regional Development Fund

VARSINAIS-SUOMEN LIITTO
EGENTLIGA FINLANDS FÖRBUND
REGIONAL COUNCIL OF SOUTHWEST FINLAND

UNIVERSITY OF TURKU

functional foods forum